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Montgomery County, Kansas

National Eutrophication Survey, Corvallis, Oreg

Prepared for

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16 ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT

ON

ELK CITY RESERVOIR

MONTGOMERY COUNTY

KANSAS

EPA REGION VII

Working Paper No. 513

With the cooperation of the

Kansas Department of Health and Environment

and the

Kansas National Guard

April, 1977

1.0

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

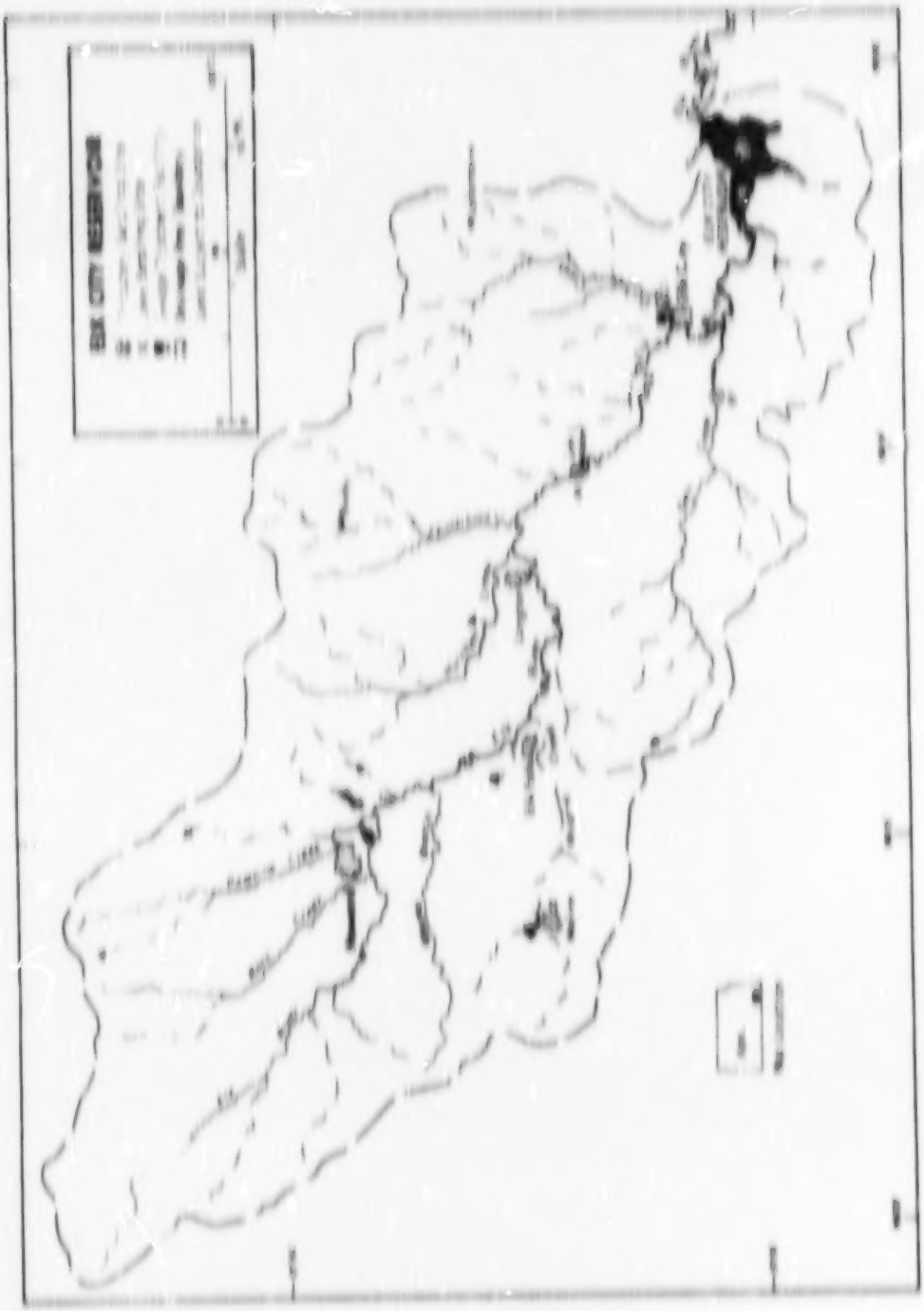
The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Kansas State Department of Health and Environment for professional involvement, to the Kansas National Guard for conducting the tributary sampling phase of the Survey, and to those Kansas wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

The staff of the Kansas Division of Environmental Health provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General Edward R. Fry, the Adjutant General of Kansas, and Project Officer Colonel Albin L. Lundquist, who directed the volunteer efforts of the Kansas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY
STUDY RESERVOIRS
STATE OF KANSAS

NAME	COUNTY
Cedar Bluff	Trego
Council Grove	Morris
Elk City	Montgomery
Fall River	Greenwood
John Redmond	Coffey, Lyon
Kanopolis	Ellsworth
Marion	Marion
Melvern	Osage
Milford	Clay, Geary
Norton	Norton
Perry	Jefferson
Pomona	Osage
Toronto	Greenwood, Woodson
Tuttle Creek	Marshall, Pottawatomie, Riley
Wilson	Russell



ELK CITY RESERVOIR

STORET NO. 2003

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Elk City Reservoir is potentially eutrophic. However, because of persistent turbidity and resulting light-limitation, primary productivity in the reservoir is low (King, 1977).

This water body ranked fourth in overall trophic quality when the 15 Kansas reservoirs sampled in 1974 were compared using a combination of six water quality parameters*. Two of the reservoirs had less median total phosphorus, none of the others had less median dissolved orthophosphorus, seven had less median inorganic nitrogen, none had less mean chlorophyll a, and 13 had greater mean Secchi disc transparency. Depression of dissolved oxygen with depth occurred at both sampling stations in June.

Survey limnologists did not observe algal concentrations or macrophytes but noted the reservoir was quite turbid during all sampling visits.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Elk City Reservoir was phosphorus-limited at the time the sample was taken (10/03/74). The reservoir data indicate phosphorus limitation in April as well.

* See Appendix A.

However, the low Secchi disc transparencies and relatively low numbers of phytoplankton (page 6) indicate primary productivity in the reservoir is light-limited rather than nutrient-limited as noted above.

C. Nutrient Controllability:

1. Point sources--Point sources contributed an estimated 6.1% of the total phosphorus load to Elk City Reservoir during the sampling year. The Howard wastewater treatment plant contributed 2.9%, the Moline facility added 1.8%, and the Elk City plant contributed 1.4%.

The present phosphorus loading of 2.23 g/m²/yr is 2.7 times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 13). However, even complete removal of phosphorus at the point-sources listed above would only reduce the loading to about 2.6 times the eutrophic loading. Because of this and light-limited primary productivity, it is not likely that point-source phosphorus control would result in any appreciable improvement in the trophic condition of the reservoir.

2. Non-point sources--It is estimated that non-point sources contributed nearly 94% of the total phosphorus load reaching the reservoir during the sampling year. The Elk River contributed 52.5%; Duck Creek, 12.4%; and the ungaged minor tributaries and immediate drainage contributed an estimated 28.3% of the total load.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 17.81 kilometers^2.

2. Mean depth: 2.4 meters.

3. Maximum depth: 12.0 meters.

4. Volume: 42.679 x 10^6 m^3.

5. Mean hydraulic retention time: 45 days (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Elk River	1,051.5	6.920
Duck Creek	163.4	1.180
Minor tributaries & immediate drainage -	409.4	3.360
Totals	1,624.3	11.460

2. Outlet -

Elk River	1,642.1**	10.870

C. Precipitation***:

1. Year of sampling: 114.5 centimeters.

2. Mean annual: 93.5 centimeters.

† Table of metric conversions--Appendix B.
†† Kring, 1977.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of reservoir.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Elk City Reservoir was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Samples for physical and chemical parameters were collected from one or more depths at one station in April and two stations in June and October (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the October visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 12.8 meters at station 1 and 1.5 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table (the June nutrient samples were not preserved properly and were not analyzed).

| | | |

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/10/74	1. Centric diatoms	664
	2. Chroomonas sp.	498
	3. Mesostigma sp.	498
	4. Cryptomonas sp.	373
	5. Gymnodinium sp.	249
	Other genera	580
	Total	2,862
06/24/74	1. Pharmidium sp.	436
	2. Centric diatoms	375
	3. Pteromonas sp.	775
	4. Chroomonas sp.	229
	5. Trachelomonas sp.	206
	Other genera	849
	Total	2,870
10/03/74	1. Chroomonas sp.	129
	2. Aphanizomenon sp.	78
	3. Cryptomonas sp.	78
	4. Cyclotella sp.	26
	5. Scenedesmus sp.	26
	Total	337

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
04/10/74	1	3.4
	2	*
06/24/74	1	0.6
	2	6.1
10/03/74	1	3.7
	2	*

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.030	0.512	6.0
0.050 P	0.080	0.512	15.2
0.050 P + 1.0 N	0.080	1.512	18.6
1.0 N	0.030	1.512	6.6

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Elk City Reservoir was high at the time the sample was taken (10/03/74). Also, the significant increase in yield with the addition of phosphorus alone indicates that the reservoir was phosphorus limited at that time. Note that the addition of nitrogen alone resulted in a yield not sig-

nificantly greater than that of the control.

The reservoir data indicate phosphorus limitation as well. The mean inorganic nitrogen to orthophosphorus ratios were 10 to 1 or greater in April and October, and phosphorus limitation would be expected. However, because of persistent turbidity, primary productivity is light-limited rather than nutrient-limited (Kring, 1977).

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Kansas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of May and June when two samples were collected. Sampling was begun in October, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Kansas District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in Salt Creek at station B-1 and the mean annual ZZ flow.

The operators of the Elk City and Moline wastewater treatment plants provided monthly effluent samples, but corresponding flow data were not available. Nutrient loads from those sources and the wastewater plant at Howard, which was not sampled, were estimated at 1.134 kg P and 3.401 kg N/capita/year; and flows were estimated at 0.3785 m^3/capita/day.

A. Waste Sources:

1. Known municipal[1] -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Elk City	481	stab. pond	182.1	Elk River
Moline	64[2]	tr. filter	644.1	Wildcat Creek
Howard[2]	1,000	tr. filter	378.5	Pawpaw Creek

2. Known industrial - None

[1] Treatment plant questionnaires.
[2] Anonymous, 1971.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Elk River	20,830	52.5
Duck Creek	4,910	12.4
b. Minor tributaries & immediate drainage (non-point load) -	11,230	28.3
c. Known municipal STP's -		
Elk City	545	1.4
Howard	1,135	2.9
Moline	730	1.8
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	310	0.7
Total	39,690	100.0

2. Outputs -

Reservoir outlet - Elk River 21,940

3. Net annual P accumulation - 17,750 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Elk River	301,015	54.4
Duck Creek	77,215	14.0
b. Minor tributaries & immediate drainage (non-point load) -	148,770	26.9
c. Known municipal STP's -		
Elk City	1,635	0.3
Howard	3,400	0.6
Moline	2,195	0.4
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	19,230	3.4
Total	553,460	100.0

2. Outputs -

Reservoir outlet - Elk River 405,870

3. Net annual N accumulation - 147,590 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Elk River	20	286
Duck Creek	30	472

* See Working Paper No. 175.

E. Mean Nutrient Concentrations in Ungaged Stream:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Salt Creek	0.106	1.404

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	2.23	1.00	31.1	8.3

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Elk City Reservoir:

"Dangerous" (eutrophic loading)	0.84
"Permissible" (oligotrophic loading)	0.42

V. LITERATURE REVIEWED

Anonymous, 1971. Inventory of municipal waste facilities. EPA Publ. OWP-1, vol. 7, Wash., DC.

Kring, R. Lynn, 1977. Personal communication (revised morphometry: reservoir turbidity and productivity). KS Dept. of Health & Environment, Topeka.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	SUR- [illegible] SEC	CHL [illegible]	SE- [illegible] M	[illegible] [illegible] P
2001	CEDAR BLUFF RESERVOIR	0.017	0.655	435,567	4.257	10,800	0.004
2002	COUNCIL GROVE	0.044	0.638	465,894	9.789	10,440	0.029
2003	ELK CITY	0.038	0.598	486,429	3.252	24,000	0.003
2004	FALL RIVER RESERVOIR	0.053	0.478	485,667	7.483	9,200	0.024
2005	JOHN REDMOND RESERVOIR	0.038	1.258	482,667	9.467	8,280	0.046
2006	KANOPOLIS RESERVOIR	0.056	0.648	487,888	16.833	10,200	0.031
2007	[illegible] RESERVOIR	0.052	0.438	483,667	12.480	9,000	0.009
2008	[illegible] RESERVOIR	0.034	0.265	498,111	38.480	24,000	0.007
2009	[illegible] RESERVOIR	0.074	0.738	486,333	16.883	12,000	0.026
2010	NORTON RESERVOIR	0.022	0.338	476,750	21.338	8,000	0.026
2011	PERRY RESERVOIR	0.055	0.478	478,571	5.634	13,440	0.007
2012	POMONA RESERVOIR	0.048	1.246	481,333	6.332	17,000	0.021
2013	TORONTO RESERVOIR	0.067	0.425	485,500	6.583	13,000	0.011
2014	TUTTLE CREEK RESERVOIR	0.062	0.478	478,667	11.278	13,500	0.067
2015	[illegible] RESERVOIR	0.021	0.265	485,222	8.857	13,400	0.004

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	2001	[illegible]	535
2	2015	[illegible]	435
3	2007	[illegible]	357
4	2003	ELK CITY	350
5	2004	[illegible]	329
-	2008	[illegible]	326
7	2013	[illegible]	303
8	2010	[illegible]	292
9	2011	[illegible]	279
10	2006	[illegible]	271
11	2012	[illegible]	267
12	2002	COUNCIL GROVE	238
13	2009	[illegible]	234
14	2005	[illegible]	194
15	2014	[illegible]	139

PERCENT OF LAKES WITH HIGHER VALUES NUMBER OF LAKES WITH HIGHER VALUES

LAKE CODE	LAKE NAME	HIGHER TOTAL P	HIGHER INORG N	SUB-HIGHER SEC	HIGHER CHLORA	15-MIN 30	HIGHER SECCHI DEPTH P	INDEX NO
2601	CEDAR BLUFF RESERVOIR	100 (140)	100 (140)	100 (140)	93 (130)	57 (80)	46 (129)	539
2602	CLARCL DRAKE	29 (40)	25 (40)	36 (50)	43 (60)	64 (90)	29 (40)	238
2603	ELK CITY	86 (120)	92 (73)	7 (10)	100 (140)	7 (10)	100 (140)	350
2604	FALL RIVER RESERVOIR	57 (80)	57 (80)	14 (20)	71 (100)	79 (110)	53 (73)	329
2605	JOHN REDMOND RESERVOIR	14 (20)	6 (20)	0 (0)	50 (73)	93 (130)	7 (10)	164
2606	KANOPOLIS RESERVOIR	43 (60)	43 (60)	29 (40)	21 (30)	71 (100)	64 (90)	271
2607	MARION RESERVOIR	64 (90)	64 (90)	43 (60)	29 (40)	86 (120)	71 (100)	357
2608	MILFORD RESERVOIR	79 (110)	82 (110)	86 (120)	0 (0)	0 (0)	79 (110)	326
2609	MILTON RESERVOIR	21 (30)	32 (50)	79 (110)	14 (20)	53 (73)	14 (20)	234
2610	NORTON RESERVOIR	7 (10)	93 (130)	64 (90)	7 (10)	100 (140)	21 (30)	292
2611	PERRY RESERVOIR	50 (70)	28 (20)	57 (80)	86 (120)	25 (30)	43 (60)	279
2612	POMONA RESERVOIR	71 (100)	7 (10)	50 (70)	64 (90)	36 (50)	36 (50)	267
2613	TORONTO RESERVOIR	36 (50)	71 (100)	21 (30)	79 (110)	36 (50)	57 (80)	303
2614	TUTTLE CREEK RESERVOIR	0 (0)	28 (20)	71 (100)	36 (50)	14 (20)	0 (0)	129
2615	WILSON RESERVOIR	93 (130)	82 (110)	93 (130)	57 (80)	25 (30)	86 (120)	436

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.393/ = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

[redacted]

[illegible]

APPENDIX D

PHYSICAL and CHEMICAL DATA

APPENDIX I

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

[illegible]

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